Glue Compression Tests on Half-Scale Prototype

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May 27, 2005

1. Introduction

The construction of NOVA requires compression between extrusions in order to obtain a strong epoxy bond. Achieving proper compression depends upon the following factors:

- Stiffness of the extrusions. If the extrusions have little stiffness then compression is needed over a wider area. If the extrusions are very stiff then the application of a compressive force as a relatively small number of positions will result in adequate compression over the entire surface.
- Stiffness of a stack of extrusions. The NOVA proposal describes a scheme in which 8 planes are extrusions are glued together and then raised as a unit and glued to the previously assembled extrusions. How stiff is this stack, how straight is it, and how can even pressure be applied over its surface to get an adequate bond between this stack and the previously assembled extrusions?
- Stiffness of the lifting fixture/strongback. How stiff does the strong back have to be in order to apply an evenly distributed force over the surface of the extrusions?
- Flatness of the extrusions. The flatness of the two surfaces being glued together will impact the glue line that is achieved. The purpose of the epoxy is to form a bond and not simply to act as a gap filler. Glue lines that are too thick (>.020") result in weak epoxy bonds.

2. Compression Tests on Half Scale Prototype

In order to begin to understand some of the issues raised in the section above a test was conducted at ANL on the half scale prototype, shown in the figure below.

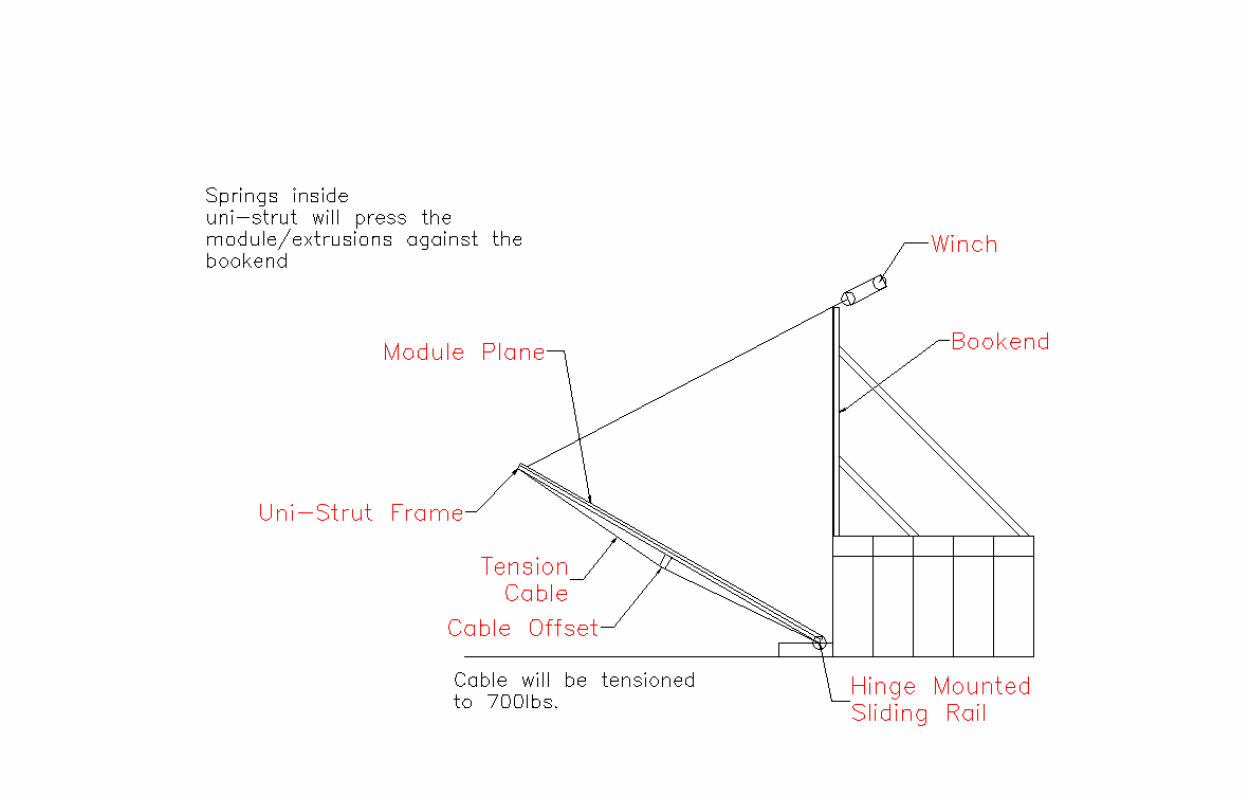

Figure 1
Schematic of Half-Scale Prototype Setup

The lifting fixture for this prototype is constructed of a uni-strut frame that is divided into 3ft square segments which correspond with the boundaries of the extrusions. Within the uni-strut frame are springs, 4 springs per each 3ft section of uni-strut. These springs extend past the uni-strut by ½" and when compressed by this ½" (so that the extrusions rest on the uni-strut) they exert a force of 13lbs each or 52 lbs over the 3ft length. This is twice the weight of the extrusions over the same area. The purpose of the springs is to exert a compressive force on the extrusions against the strong back in order to achieve a good glue bond. The springs were 5/8" in diameter and had a spring constant of 26 lbs/in.

In order to evaluate how much compression is achieved a dry assembly of the extrusions was made. The vertical extrusions were placed on the lifting frame first and the horizontals placed on top of them. This test had to be performed with horizontal extrusions that did not have the manifolds already glued on them. It had been found previously that the extrusions with the manifolds already glued on them interfered with the vertical extrusions and would not lie flat on them because of the large fillet of epoxy that had been place in the corners in order to achieve a good seal.

Pieces of mylar 14" square were place at the 6 locations shown in the figure below. The mylar sheets were placed in the center of each square formed by the uni-strut frame and therefore were in areas with the least amount of compression. The mylar sheets were placed at these locations on the interface between the extrusions and the bookend and between the horizontal and the

vertical extrusions. Beads of epoxy approximately 10” long were place in an X pattern on each set of mylar as shown in the pictures below. The extrusions were then raised against the bookend.

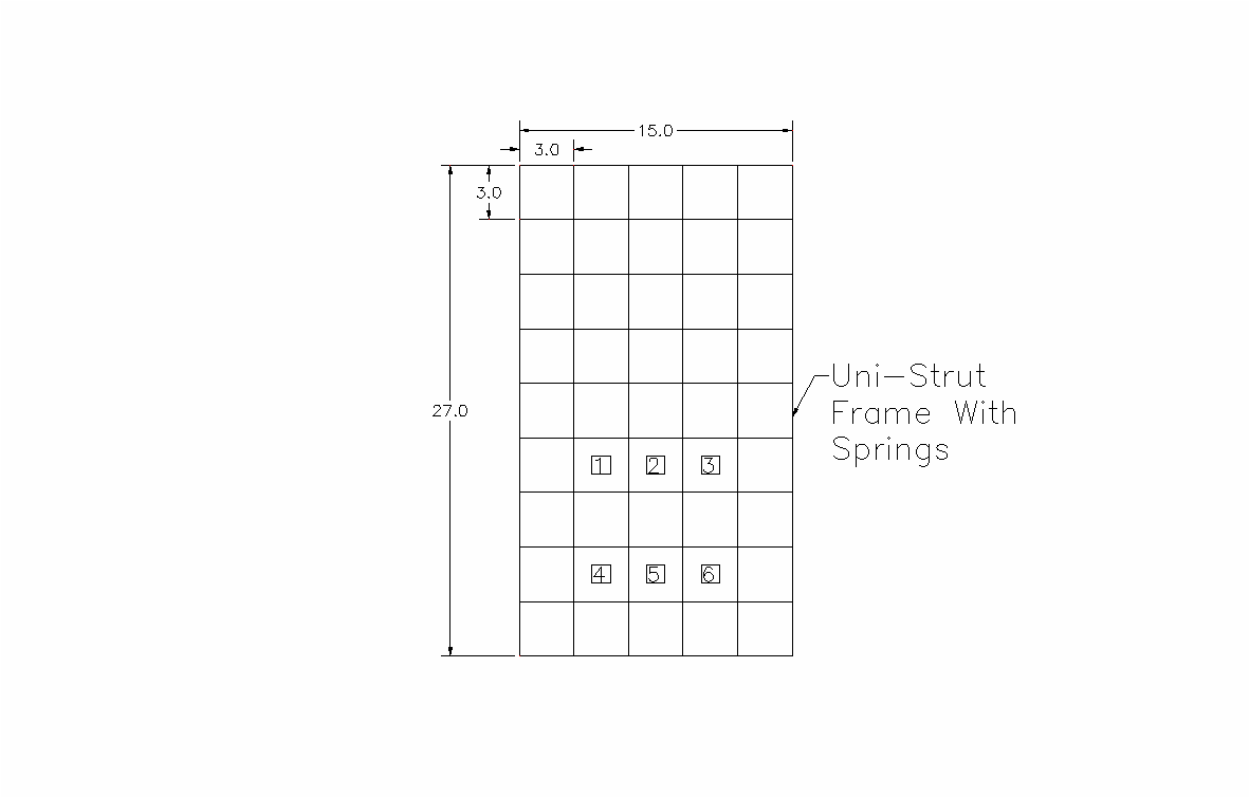

Figure 2
Location of Mylar Compression Samples

It was observed that the springs in the middle of the frame were fully compressed and the extrusions made contact with the frame. The springs on the outside edge, however, were barely compressed at all.

Figure 3
Glue Beads and Mylar Before Compression

Figure 4
Compressed Spring Between Uni-Strut and Extrusion

3. Results

The pictures below show the compression each glue sample. The thicknesses of the samples were measured and are listed in the table below. The samples labeled "A" were between the bookend and the horizontal extrusions, the samples labeled "B" were between the vertical and horizontal extrusions.

Glue Thickness After Compression

	Position Between Extrusions or Bookend	
	A	B
1	.036"	.033"
2	.029"	.038"
3	.039"	.032"
4	.020"	.035"
5	.022"	.029"
6	.022"	.033"

While the extrusions were being compressed by the lifting fixture a long shim .005” thick was inserted between the horizontal and vertical extrusions as an additional test. This shim could not be inserted when aligned with the unistrut cross members with springs but could be inserted 3ft in between the uni-strut members. This indicates that extrusions are relatively flexible and are being compressed to a much greater extent in the area of the unistrut and that the level of compression drops off away from the uni-strut support members.

Figure 5
Glue Sample 6A After Compression

Figure 6
Glue Samples/Mylar on Wall

4. Conclusions - Further Work

Before performing the final assembly of the half scale prototype some further work will be done to understand the compression between the planes. The test described above will be repeated but with test samples at 16 positions throughout the prototype surface. In addition to putting samples in the center of the 3ft square formed by the uni-strut frame, some samples will be placed directly over the uni-strut frame in order to see if the glue has greater compression. The compression observed in this initial test shows that the maximum glue line thickness is being achieved in the area between the springs. If the glue line thickness increases to values larger than those seen in this test then the strength of the epoxy will begin to diminish.

This test has demonstrated that it is important to provide compression over the entire surface of the extrusions during assembly. It will not be sufficient to simply have a handful of points over the surface of the extrusions where compression is applied if a uniform compression and coverage of the epoxy is desired. Rather, a scheme needs to be developed for the assembly of the full size detector for applying a uniform pressure over the entire surface of the extrusions.

An additional calibration test will be done to further understand the relationship between the compressive force and the glue squeeze out. A glue bead similar to the one used in the tests described above will be compressed between two 2ft. square commercial extrusions. A compression weight of 0, 5, 10, 15 lbs will be applied to the center of four test samples. After curing the thickness of the epoxy will be measured. This is one further test that will give some indication of the compressive force needed to achieve specific glue line thicknesses.